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IMPACT of science on society

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MAR 4 1952
PERIODICAL
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VOL. II. No. 1. JANUARY-MARCH 1951

IN THIS ISSUE ARTICLES BY

R. J. Forbes
Georges Friedmann
Lewis Mumford

AND

Technology and Society

ABSTRACTS

PUBLISHED BY UNESCO PARIS, FRANCE

Price per copy: 25 cents. 1s.6d. 75 francs. Yearly subscription: $1.00 6s. 300 francs

UNESCO SALES AGENTS

ARGENTINA Editorial Sudamericana, S.A., 500, Buenos Aires.

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UNION OF SOUTH AFRICA Van Schaik's Bookstore (Pty.), Ltd., P.O. Box 724, Pretoria.

UNITED KINGDOM H.M. Stationery Office: P.O. Box 569, London S.E.1.

UNITED STATES OF AMERICA Columbia University Press, 2960 Broadway, New York 27, N.Y.

URUGUAY Centro de Cooperacion Cientifica para la America Latina, Unesco, Bulevar Artigas 1320, Montevideo.

IMPACT

of science on society

VOL. II. No. 1 JANUARY-MARCH 1951

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P A R I S

CONTENTS

PRR.
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I34

FOREWORD 3

PART ONE. ARTICLES.

Technology and Society, by Professor R. J. Forbes. 7
Technics and Science, by Lewis Mumford 10
The Technocrats and the Technicians' Civilization, by Georges Friedman 12

PART TWO. TECHNOLOGY AND SOCIETY: ABSTRACTS

I. General. 17
II. Antiquity 19
III. The Middle Ages, their roots and the rise of applied science . . 22
IV. The Industrial Revolution and its aftermath. 24
Author Index 27
Index of Periodicals. 29

P.R.R.

FOREWORD

The process of "mechanizing" human labour, which has revolutionized the life of industrial societies, can be traced back to the eighteenth century. As man becomes ever more swiftly absorbed into a world of technology that increasingly isolates him from his natural environment, it becomes more and more difficult to imagine what men of the future will be like. So, rather than attempting to guess at the characteristics of future generations, we have concentrated on assembling historical material for a later large-scale survey.

Technology plays a part in most activities of the civilized world, and its effects on each of them are many and complex. It is mainly the psychological and social effects that, in this issue of Impact, *we shall consider. On the one hand we have, as a result of the mechanization of his various working processes, an incipient "mechanization" of the worker himself, a tendency towards the "dehumanization" of humanity; on the other, we have a rise in the standard of living, and a greater measure of prosperity for an increasing number of workers, and hence greater possibilities for a more human, more individual culture, in short, a tendency towards the "superhumanization" of humanity. Emphasis on one or the other of these aspects, as the case may be, results in contradictory conclusions being formed. Some regard industrialization as the death-blow to a humanism which represented and still represents, for cultured people throughout the civilized world, a heritage of thousands of years of thought and effort; others see in it the dawn of a new age, holding out all those brilliant prospects in the material sphere without which there can be no spiritual progress. May it not be too soon to decide which of these two views is right, and should we not suspend judgment until further and deeper probings have provided us with the proper answer? Can we not conclude, here and now, that we are embarked upon an adventure which can lead us in either direction, that in solving this grave problem we are not simply at the mercy of facts, and that it is for man to turn his own technical progress to good account and so to shape his destiny that it leads him towards material as well as towards intellectual and moral advancement?*

In any case, whatever future prospects and the solutions favoured may be, this is a burning question today—a question which, more or less openly, comes to the fore in a large section of contemporary thought. For that reason, we feel it is not out of place to devote to it a certain amount of bibliographical attention.

Some surprise might be felt that most of the reports connected with this enquiry deal with the history of techniques, and that comparatively few are concerned with the current problems of mechanization and its effects on society. The reason is that although those effects are indeed referred to—in anything from the most sombre to the most optimistic terms—they have rarely been studied systematically. Studies of factual detail, on the other hand, are constantly on the increase; but either they are conducted from the point of view of a particular discipline, like applied psychology or the sociology of knowledge, and would be irrelevant here; or else they bear on the repercussions of some separate science or technique. Such studies will be dealt with in subsequent issues of Impact, *which will be devoted to more specialized subjects. For example, an article by Professor Ogburn will shortly appear on the social effects of aviation.*

We have therefore confined ourselves here to purely general studies. The fact that they are few in number is probably due to our inability to view in perspective the events which are taking place around us and from which it is difficult to detach ourselves; moreover, the accumulation of facts and documents which have not yet been sifted prevents us from obtaining a clear, general view. Hitherto, apart from detailed research and surveys, the problem has been approached mainly from an historical angle, although many authors have merely written a history of techniques without attempting to trace the connexion between them or their influence on the history of mankind.

In view of the large number of historical documents available, we have arranged the abstracts in this issue in chronological order, adapting to our purpose the broad classical divisions of history. Had our research been more advanced, it would no doubt have been better to substitute for, or at least add to, this chronological arrangement a "rational" one based on the various spheres influenced by the development of technology: professional, family, cultural and personal life, leisure and so forth. Logical though it may be, however, such an arrangement would be premature here.

In conclusion, we would express our thanks to Professor Forbes of Amsterdam University, to whom we are indebted, not only for an introductory article, but for the general plan of this study, as well as for most of the bibliographical information and abstracts which it contains.

The Editor of Impact.

PART ONE

Articles

Technology and Society

by

Professor R. J. Forbes,
of Amsterdam University

Of late historians have begun to appreciate the history of technology as part of the history of civilization and sociologists have recognized its value for the study of the impact of technology on modern society. Though the history of technology as presented in modern handbooks is far from complete and shows some serious gaps, more particularly in Antiquity, the data collected are sufficient to permit an attempt to assess the social effects of technology in the past. Such studies will seldom be found in histories of technology, as engineers and technologists have not often bothered to give more than the technical evolution and they usually lack the necessary historical or sociological training.

The history of technology can be interpreted as a long struggle for co-operation between craftsmen and scientists. The one-sided contact between these two groups of students of natural objects in pre-classical Antiquity was loosened in classical times through sociological factors. Only by the end of the Middle Ages was the slow progress of technology by trial and error enlivened, as science awoke to the social importance of technology and as the leading craftsmen established a link with theoretical science. Since then, co-operation has become closer and closer. From the seventeenth century onwards the scientific societies played an important part in this process, and thus laid the foundations for the establishment of technology as applied science, as we know it today.

The impact of technology on society is both direct and indirect. The direct impact is generally the most easy to study and assess. Technology is bent on extending and improving material culture by observing and using natural objects and forces. Assisted by extraneous means, Man the Maker devises methods of changing natural materials into artefacts or products that he uses. Hence the old craftsman was a utilitarian many centuries before science began to point to the benefit of mankind as one of the goals of theoretical study of Nature.

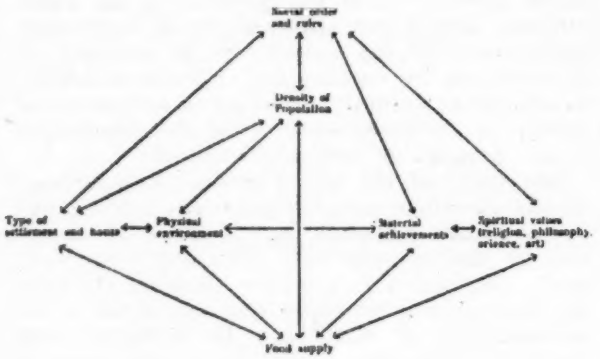
Whatever its aims and methods may be, technology is limited from the very start by Nature itself. The materials it uses have certain natural characteristics beyond which the technologist cannot go. Again, the craftsman or engineer uses and harnesses certain forces of nature, but these too have their natural limits. Thirdly, the history of technology coincides more or less with that of the machine, that is the instrument by which man partly or wholly relieves himself of the work to be done. As soon as he succeeds in getting Nature to do his job, he has created some form of prime mover. The story of technical achievement during the centuries, can be written as the story of ever-increasing concentration of energy by means of prime movers on to the material to be transformed. Hence the achievements of technology during each period should first be assessed by its efficiency in working the available materials, in harnessing natural forces and in concentrating energy at the point needed for the production of the artefact or technical product.

The study of the social effects of technology should therefore always begin by investigating the available materials and sources of energy and by determining how efficiently they were used. This involves a proper study of the tools and instruments developed and if possible actual measurement of what can be achieved with them, because this is the only safe way of assessing this efficiency critically.

This immediately leads us to the main force behind the evolution of technology, the inventor, whose discoveries and inventions are the bricks from which the house of material civilization is built. The methods of the inventor did change during the ages, but then as now his powers were often overrated and misrepresented. Here again we find that the inventor, like the common craftsman, is not only limited by the natural characteristics of the materials and means he uses. The forms of his products are also limited by the laws of his spiritual world. The Egyptian sculptor, so characteristically called "he who makes alive", produced statues which had to conform to certain rules in order to be endowed with magical potency by the final "Ritual of Opening the Mouth" and serve the community in the desired way. As an artist and a sculptor he was able to shape his material in many other ways, as is proved by the models from his workshop, but the shape of the final product was limited by convention. We find the same when we examine tools, arms, processes and techniques. Social patterns backed by religious and philosophical concepts place restrictions on the evolution of the material equipment, even in our days of utility and materialism.

The fact that Man the Maker chooses certain of the restricted possibilities should make us wary of adopting a materialistic attitude towards the history of technology. Even in primitive

societies today, material culture is linked up with many aspects of society (see figure). If therefore a given civilization will select, from the past or from its own experience, those forms that suit it, this shows that Man the Maker can never be separated from Man the Thinker. With regard to the inventory of discoveries and inventions from which each period and each civilization chooses, we can truly speak of evolution, because nothing gets lost but only pushed into the background. This is certainly not true in the history of ideas or spiritual values. Such a belief as polytheism, once a strong factor casting its shadow on technology too, has vanished forever from the Western



FACTORS IN PRIMITIVE CULTURE

world. This brings us to the indirect impact of technology on society. Technology enriches material culture and hence takes part in shaping society, not only directly, by producing goods and things, but also because in the act of creating these material achievements it acquires data that are absorbed into the spiritual world and enrich it in many ways. Conversely, the world of spiritual values has acted upon technology by making and directing its choice of the possibilities embodied in the materials and forces at its disposal.

This action of technology on society through accumulation of spiritual values, and the indirect achievements thus obtained, are most difficult to assess. A rough survey of the history of glass will demonstrate this. The earliest techniques of moulding heated sticks of glass on clay cores made only small bottles for perfumes and ointments possible. In the first century B.C. the discovery of blowing and annealing glass opened up the possibility of shaping household articles from glass, like bottles and vases, created a competitive material for household utensils, and made possible the substitution of glass for mica as a material for window-panes Then the invention of spectacles (around 1380), and a few centuries later that of telescopes and microscopes, opened up new prospects, this time in scientific research, where glass vessels had already assisted the alchemist to study chemical reactions better. The advent of purer chemicals and casting techniques at the end of the eighteenth century provided the glass industry with the possibility of creating new and purer types of glass, and their combination made more efficient scientific instruments possible. What this meant to science and to humanity in general cannot be expressed in these few lines.

The difficulty of tracing those threads in the tapestry of civilization which belong to technology is increased when we fail to shake off our custom of comparing past civilizations with ours and transplanting modern ideas and slogans into them. Production figures and the output of factories, "invention intensity factors" or other numerical data, purely economic or political reasoning, will lead us to wrong conclusions. The very place of technology in an ancient society should be investigated, the status of its craftsmen, engineers and inventors, the meaning of "labour", "slavery", "machine" and all those words associated with technology should be studied. Did words like "progress", "mechanization", "efficiency", "class struggle", "proletariat", "factory", "production process", "employer" have any meaning and if so, was it perhaps a different one from that of today? It is well known that the study of the meaning of fundamental terms in the history of science has led to the recognition that the intrinsic value of such words shifts in the course of centuries as science develops. The same is true for those that pertain to technology, and its social effects could never be judged without this knowledge.

The measure of co-operation between science and technology should also be carefully studied. This should be done with due recognition of the true nature of invention, and due regard to the historical data on the transmission of discoveries and inventions. Invention is a complex of very diverse elements, and the new "combination" of data which results in the invention is not only determined by the scientific grasp of the inventor on these data but by the fact that as a child of his period he is directed in his selection. Invention is a slow, a very slow, process of accretion of little details, an evolution somewhat like a biological process, but it can hardly ever be blamed on one man only. All this long chain of inventions is governed by the spiritual world in which it takes form. The inventions are prompted by the imaginative power of that world and its real or imaginary "needs" They are often predicted by those dreamers of the world who are the real spiritual leaders of their civilization. Gradual changes in a culture, such as the growth of wealth, education and industrialization, will evoke inventions which, like plants, have a short active life, persist, but are rarely rejuvenated. Moreover "invention is the mother of necessity" rather than the reverse statement that is so commonly accepted.

The diffusion of inventions and discoveries is another important factor not to be overlooked, nor should we project the rapid spread of these inventions in modern times back into the past. For early times show even more clearly than the present day that the transmission of ideas and techniques is not directly related to the mobility of man, to the development of communication. The resistance of "recipients" and "transmitters" of discoveries and inventions varies greatly. Such resistance is the direct result of the structure and fundamental principles of culture itself. Spiritual values may defer the acquisition of material achievements much longer than will the lack of technical knowledge. Still, research on this transmission, and into the question of where and when these new discoveries and inventions buttress or conflict with the "receiving" civilization is sorely lacking in the history of technology.

The impact of technology on society can also be studied from the other end. Sociology has rightly rejected its former belief in social evolution as something akin to biological evolutionary processes. For society is even more closely bound to the spiritual world of its period than is technology. The social order is firmly founded on the religious and philosophical tenets of a civilization. It is not static, but its changes are apt to be slow, as basic tenets will not suddenly change. Here the way in which new techniques and technical products are prompted, acquired and absorbed can be traced and interpreted with a proper knowledge of the basic techniques and the scientific principles involved. A study of the changes in social structure, its forms and its terminology can yield invaluable data for the history of technology.

The most urgent requisite for the history of technology is the creation of histories of technological equipment, tools and instruments as well as processes, with proper attention given to the social impact. Up to the present moment this field has been practically unexplored, and it is bound to yield more material concerning the social impact of technology than any other. Careful attention should be given at the same time to the scientific and technical terminology of the period, in order to assess the social consequences at their proper value. Only when this is achieved can we judge more accurately the impact of technology on society.

Technics and Science

by

LEWIS MUMFORD

The detailed history of the steam engine, the railroad, the textile mill, the iron ship, could be written without more than passing reference to the scientific work of the period. For these devices were made possible largely by the method of empirical practice, by trial and selection: many lives were lost by the explosion of steam-boilers before the safety-valve was generally adopted. And though all these inventions would have been the better for science, they came into existence, for the most part, without its direct aid. It was the practical men in the mines, the factories, the machine shops and the clockmakers' shops and the locksmiths' shops or the curious amateurs with a turn for manipulating materials and imagining new processes, who made them possible. Perhaps the only scientific work that steadily and systematically affected the paleotechnic design was the analysis of the elements of mechanical motion itself.

With the neotechnic phase, two facts of critical importance become plain. First, the scientific method, whose chief advances had been in mathematics and the physical sciences, took possession of other domains of experience: the living organism and human society also became the objects of systematic investigation, and though the work done in these departments was handicapped by the temptation to take over the categories of thought, the modes of investigation, and the special apparatus of quantitative abstraction developed for the isolated physical world, the extension of science here was to have a particularly important effect upon technics. Physiology became for the nineteenth century what mechanics had been for the seventeenth: instead of mechanism forming a pattern for life, living organisms began to form a pattern for mechanism. Whereas the mine dominated the paleotechnic period, it was the vineyard and the farm and the physiological laboratory that directed many of the most fruitful investigations and contributed to some of the most radical inventions and discoveries of the neotechnic phase.

Similarly, the study of human life and society profited by the same impulses toward order and clarity. Here the paleotechnic phase had succeeded only in giving rise to the abstract series of rationalizations and apologies which bore the name of political economy: a body of doctrine that had almost no relation to the actual organization of production and consumption or the real needs and interests and habits of human society. Even Karl Marx, in criticizing these doctrines, succumbed to their misleading verbalisms; so that whereas *Das Kapital* is full of great historic intuitions, its description of price and value remains as prescientific as Ricardo's. The abstractions of economics, instead of being isolates and derivatives of reality, were in fact mythological constructions whose only justification would be in the impulses they excited and the actions they prompted. Following Vico, Condorcet, Herder and G. F. Hegel, who were philosophers of history, Comte, Quetelet, and Le Play laid down the new science of sociology; while on the heels of the abstract psychologists from Locke and Hume onward, the new observers of human nature, Bain, Herbart, Darwin, Spencer, and Fechner integrated psychology with biology and studied the mental processes as a function of all animal behaviour.

In short, the concepts of science, hitherto associated largely with the cosmic, the inorganic, the "mechanical", were now applied to every phase of human experience and every manifestation of life. The analysis of matter and motion, which had greatly simplified the original tasks of science, now ceased to exhaust the circle of scientific interests: men sought for an underlying order and logic of events which would embrace more complex manifestations. The Ionian philosophers had long ago had a clue to the importance of order itself in the constitution of the universe. But in the visible chaos of Victorian society Newlands' original formulation of the periodic table as the Law of Octaves was rejected, not because it was insufficient, but because Nature was deemed unlikely to arrange the elements in such a regular horizontal and vertical pattern.

During the neotechnic phase, the sense of order became much more pervasive and fundamental. The blind whirl of atoms no longer seemed adequate even as a metaphorical description of the universe. During this phase, the hard and fast nature of matter itself underwent a change: it became penetrable to newly discovered electric impulses, and even the alchemist's original guess about the transmutation of the elements was turned, through the discovery of radium, into a reality. The image changed from "solid matter" to "flowing energy".

Second only to the more comprehensive attack of the scientific method upon aspects of existence hitherto only feebly touched by it, was the direct application of scientific knowledge to technics

and the conduct of life. In the neotechnic phase, the main initiative comes, not from the ingenious inventor, but from the scientist who establishes the general law: the invention is a derivative product. It was Henry who in essentials invented the telegraph, not Morse; it was Faraday who invented the dynamo, not Siemens; it was Oersted who invented the electric motor, not Jacobi; it was Clerk-Maxwell and Hertz who invented the radio telegraph, not Marconi and De Forest. The translation of the scientific knowledge into practical instruments was a mere incident in the process of invention. While distinguished individual inventors like Edison, Baekeland and Speery remained, the new inventive genius worked on the materials provided by science.

Out of this habit grew a new phenomenon: deliberate and systematic invention. Here was a new material: problem—find a new use for it. Or here was a necessary utility: problem—find the theoretic formula which would permit it to be produced. The ocean cable was finally laid only when Lord Kelvin had contributed the necessary scientific analysis of the problem it presented: the thrust of the propeller shaft on the steamer was finally taken up without clumsy and expensive mechanical devices, only when Michell worked out the behaviour of viscous fluids: long distance telephony was made possible only by systematic research by Pupin and others in the Bell Laboratories on the several elements in the problem. Isolated inspiration and empirical fumbling came to count less and less in invention. In a whole series of characteristic neotechnic inventions the thought was father to the wish. And typically, this thought is a collective product.

While the independent theoretic mind was still, naturally, immensely stimulated by the suggestions and needs of practical life, as Carnot had been stirred to his researches on heat by the steam engine, as the chemist, Louis Pasteur, was stirred to bacteriological research by the predicament of the vintners, brewers, and silkworm growers, the fact was that a liberated scientific curiosity might at any moment prove as valuable as the most factual pragmatic research. Indeed, this freedom, this remoteness, this contemplative isolation, so foreign to the push of practical success and the lure of immediate applications, began to fill up a general reservoir of ideas, which flowed over, as if by gravity, into practical affairs. The possibilities for human life could be gauged by the height of the reservoir itself, rather than by the pressure the derivative stream might show at any moment. And though science had been impelled, from the beginning, by practical needs and by the desire for magical controls, quite as much perhaps as by the will-to-order, it came during the nineteenth century to act as a counterweight to the passionate desire to reduce all existence to terms of immediate profit and success. The scientists of the first order, a Faraday, a Clerk-Maxwell, a Gibbs, were untouched by pragmatic sanctions: for them science existed, as the arts exist, not simply as a means of exploiting nature, but as a mode of life: good for the states of mind they produce as well as for the external conditions they change.

Other civilizations reached a certain stage of technical perfection and stopped there: they could only repeat the old patterns. Technics in its traditional forms provided no means of continuing its own growth. Science, by joining on to technics, raised so to say the ceiling of technical achievement and widened its potential cruising area. In the interpretation and application of science a new group of men appeared, or rather, an old profession took on new importance. Intermediate between the industrialist, the common workman, and the scientific investigator came the engineer.

From *Technics and Civilization* by Lewis Mumford. Used by permission of Harcourt, Brace and Company, New York.

The Technocrats and the Technicians, Civilization

by
GEORGES FRIEDMANN
Professor at the Conservatoire National des Arts et Métiers
and at the Institut d'Etudes politiques of Paris University

Howard Scott's physico-chemical, like Burnham's bureaucratic, technocracy isolates the technicians from the mass of human problems created by technology, just as Taylor isolated them—and more successfully—in the purely industrial sphere. As a result, the type of technician depicted not only by Taylor, but also by Howard Scott and Burnham, has been criticized and outstripped by the new trends in the scientific organization of labour. What did Taylor offer us? The type of engineer who views everything from the angle of the machine, and who pays no attention at all to the human factor, or to the physiology, psychology and sociology of labour. What does Scott give us? Physico-chemistry, which calculates energetic surfaces, while remaining as it were suspended in a social vacuum. And what does Burnham describe? Techno-bureaucrats who form what might almost be termed a Fifth International spurning frontiers, and who leave out of account social determinations and the realities of class warfare.

In practice, however, what is it that has been happening almost all over the world in the past 20 years or so? The technicians have been making efforts which imply a much more complex and a much more human approach. The best of them—and their number is by no means negligible, not only in industry and commerce, but also in workshops, offices, managements and personnel services—form a veritable elite which is gradually discovering the importance of the human sciences and asserting the necessity for co-operation, both among themselves and with the techniques of production, administration and distribution—a form of co-operation completely left out of acount by the technocrats.

We have no space here to go into the causes of an evolution set in motion by a great variety of factors and with its own historic inevitability. It would, incidentally, be easy to show why the function of technicians tends to evolve. But the facts are there and that suffices. In the United States, despite the survival of the Taylor Society and of many of the master's disciples, Taylorism has gradually been outmoded since its author's death, to be overtaken by a movement which may be briefly described as "personnel relations". It recognizes the importance of the human factor, of physiological and psychological determinism and, in its most recent form, even goes so far as to admit that the problems of all and every type of undertaking must be viewed from their social angle.

I have no intention whatever of compiling a complete list here; I merely propose to note certain landmarks in this evolution, both in France and abroad.

The first Personnel Management schemes in industry were still rather sketchy around 1930, but very soon a number of universities set up institutes specializing in the study of these problems, among them Harvard, where Elton Mayo inaugurated the famous, and by now classical, Western Electric Survey. In Chicago itself, "the city with the tentacles", which has one of the biggest centres for scientific sociology in the United States, an "Industrial Relations Committee" was formed to carry out systematic surveys in a large number of firms, with the concurrence of the managements and the trade unions. The most important of these early observations were recorded in a little book as rich in substance as it is slim in size—*Industry and Society*, edited by W. F. Whyte, since appointed to Cornell University. At the same time, a mass of literature is coming out in the United States on these new conceptions of organization, and is but little known in France. Textbooks are being published, such as S. D. Hoslett's *Human Factors in Management*, which shows that these problems have already attained the status of disciplines.

France has also been affected by this movement, but only sporadically. The CNOF (Comité national de l'organisation française), formerly a passionate believer in Taylorism, has evolved: it no longer considers that Taylorism is the last word in management and its line has further been dented by the industrial relations movement, so much so that it is at present organizing a congress whose very title is significant: *"Les problèmes sociaux de l'organisation du travail"* (Social problems in the organization of labour). Ten years ago, this would not have been thought of. Moreover, the CEGOS is applying itself to organizing labour with a view to greater co-operation with the human sciences, and psychologists and sociologists are being called in through the intermediary of the Bureau de Psychologie industrielle and the Institut d'administration publique. Again, the Bureau des temps élémentaires (BTE) has only quite recently completed a film made jointly with a big machine-tool manufacturing company. The film shows a new model of a lathe, with its

characteristics and method of functioning, but it has been *"humanized"*, that is to say, constructed by the manufacturer in co-operation with psysiologists and industrial psychologists.

Here again we see the mental evolution which has occurred in certain technical circles, and one of whose manifestations among French employers is the group known as the *Jeunes Patrons*. A *Centres d'études des problèmes humains* has recently been set up in Brussels, with the principal object of studying industry in conjunction with the human sciences. In England, there has also been a significant change of attitude. In English circles connected with scientific management, I was recently told on every side: "What matters most for us now is not technology, but human factors, both psychological and social." The National Institute of Industrial Psychology in London, for instance, the principal organization in Great Britain for industrial psychology, has definitely altered its doctrines and activities in this direction. The British Institute of Management, which has just received £150,000 from the Labour Government as a birthday present, shares this concern. There is another institute in England which is little known in France, and I am happy to bring this young and lively institution to the notice of all who are interested in these problems. It is the Tavistock Institute for Human Relations, where doctors, many of whom were psychiatrists during the war and acquired a wealth of experience of individual and collective psychology, have turned to industrial problems and field work in the factories, provided they are called in with the full agreement of the workers. Their programme includes close co-operation between doctors, psychologists, technicians, engineers, sociologists and economists

Let there be no mistake: the evolution of which we speak is still far from universal. Taylorism is still a powerful force, and in every country there are still many engineers of all grades and many heads of businesses whose outlook is narrow and whose attention is almost wholly focused on technical questions, to the exclusion of the human factor, of which they are either ignorant or afraid. It is equally clear that we are omitting from industrial relations movements—which are here considered scientifically—the partly naïve and partly astute use of psychotechnics mainly by certain employers' circles in the United States, and with the sole aim of sending up output and profits.

It is, however, undeniable that technicians are less and less of the "technicist" or "technocrat" type, but have grasped the need to observe industrial facts in the light of the human sciences. This is a step forward in our knowledge of social nature, a branch of knowledge foretold and desired by Auguste Comte when he founded sociology as a positive science.

The facts of industry and trade are destined to an increasing extent to form the future subject-matter of the human sciences. I should like to emphasize in conclusion that this evolution is of capital importance for the future of the highest human values, since, to my mind, danger threatens them not so much from some mythical "managerial revolution" as—in the most precise psychological meaning of the term—from the *anarchic* way in which modern man is being *conditioned by his technical environment which is becoming more and more impenetrable.* I merely mention in passing that our present-day technical environment is wholly different from the natural environment in which Western civilized man lived in the pre-machine age. Then, too, he was surrounded by objects, elements and animals, but he was not in any way subject to the artificial conditioning which is developing so intensively today. Indeed, the technical environment in which we are bound to live henceforward is formed by a mass of increasingly complex techniques—*production* techniques, in the factory, in agriculture and in offices: *communication* techniques, which put men in touch with each other and which range from Chappe telegraphy to television; *transport* techniques on the ground, on and beneath the seas, and in the air, and which are becoming ever more specialized; and techniques of *leisure*, which include some of those already mentioned, a motor car, for example, being a means of transport or an instrument of work or leisure, according to circumstances. And in this category let us not forget those monster forces of our times—the film and the radio—whose impact on the psycho-social conditioning of mankind has not yet been studied.

All these techniques are building round man a new environment. They constitute what Marcel Mauss, in his admirable statement to the first *Semaine de Synthèse*, called "the facts of civilization". They are to be found in societies of varying economic structure, but incorporated and utilized in different ways. Taken together, they are characteristic of the technicians' civilization of the twentieth century, which the technocrats wholly ignored, while also entirely neglecting its profound influence on modern man.

Here again we might recall that great thinker, Cournot, who foresaw this evolution and analysed it in what he termed the transition from the "vital" to the "rational". Contemporary man's technical environment grows ever denser while bringing stronger and stronger, but still uncontrolled, pressure to bear upon him. Because they ignored these facts, the various technocracies were unable to reset in their proper place within the framework of the technicians' civilization the real problems raised by technical progress. Theirs are, after all, but weak ideologies, condemned to oblivion because divorced from a very important part of reality.

Need I emphasize that there is no question of condemning or rejecting this modern technical environment in the name of some intellectual or sentimental consideration? This environment *is the reality* with which we are now grappling. We must face it, study it with all the resources of our knowledge, and endeavour to dominate and humanize it.

Thus the only real technocracy to be feared, and which might prove fatal to our civilization, is one whose techniques exercise and would in the long run continue to exercise an obscure and anarchic influence on societies and individuals. Without any doubt, the technocrats and the worshippers of technology are themselves a harmful influence, just as, incidentally, are all those who control, or believe they control, techniques such as the film, press or radio, *without real knowledge* of the media they handle, without real knowledge of their impact on men, and who in any case use these media *without understanding the high moral purposes* they should serve.

To my way of thinking, the gravest problem of our age is how to dominate, one might almost say, how concretely to humanize the technicians' civilization. The technocrats of all schools have been blind to it, and it is this which makes their doctrine essentially pernicious. I do not propose, in concluding this rapid survey, to tackle so distressing a question here. I will merely say that we face both a social problem of organising a genuinely rational and material system of production and distribution, and an individual—I might even say a moral—problem which requires that man shall set consciously and perseveringly to work upon himself.

Extract from the lecture "Les technocrates et la Civilisation Technicienne" by Georges Friedmann, published in *Industrialisation et Technocratie*, a collection published by the firm of Armand Colin, under the direction of Georges Gurvitch.

PART TWO

Technology and Society Abstracts[1]

1) There are certain number of abstracts that could have been included in this bibliography which have already appeared in the first issue of *Impact* (Vol. I, Mai, April-June 1950). In particular, abstracts relating to works by.

J. D. Bernal; V. G. Childe; G. N. Clark; I. B. Cohen; B. Farrington; C. C. Furness; S. Giedon; W. E. Houghton; S. Lilley; E. Mayo; R. K. Merton; L. Mumford; W. F. Ogbrun; B. Stern; D. J. Struik; E. Zilsel
abstracted according to the following numbers
13; 19, 20; 21; 22; 32, 33, 34; 36; 41; 46; 53, 54, 55; 58; 60; 62; 65; 86; 88; 98, 99, 100, 101.

I. *General*

407 AYMARD, Joseph. *La main, l'outil, la machine.* "Bibliothèque du peuple", No. 51. Presses universitaires de France, Paris, 1942, 64 pp.

This small popular treatise is intended to draw attention to the psychological and social aspects of the problem of mechanism, and not to give an historical outline of technique throughout the ages. But it considers technical improvements in their chronological order: hand tools and instruments, the historical beginnings of mechanism, the spread of mechanism in France and England, and mechanism in the nineteenth century, the century of steam and electricity. In conclusion, the author examines the relations between mechanism and capitalism, and gives a definition of an ideal "corporatism" to which mechanism—which has an ever-greater need of man's intelligence—would not be an obstacle.

408 BURY, J. B. *The Idea of Progress.* MacMillan, London, 1920, 350 pp.

Though mainly a brilliant historical essay on the social effects of science, it is important in stressing that the idea of progress was virtually inexistent before the seventeenth century. The new scientific discoveries and theories led to the belief that the world was progressing towards a better state, at least as far as material civilization was concerned.

409 DUCASSÉ, Pierre. *Histoire des techniques.* Presses universitaires de France, Paris, 1945, 136 pp.

A short outline of the history of engineering, mainly mechanical, which attempts to introduce some economic and social background Contains some interesting suggestions for future historians of technology.

410 FORBES, R. J. *Man the Maker, a History of Technology and Engineering.* Schuman, New York, 1950, 355 pp.

This book is the first attempt to relate the history of technology to the general cultural background, by tracing through the ages certain techniques such as metallurgy, civil engineering, transport, textiles, glass and chemical technology. The social and economic influences sustaining these fields of technology and the influences of the new techniques on society cannot of course be described in this limited space.

411 FOURASTIÉ, Jean. *Machinisme et bien-être.* Editions de minuit, Paris, 1951, 256 pp.

In this book the consequences of mechanization are considered, not from the standpoint of the worker and producer, but from that of the consumer, his well-being and his leisure. The first part deals with the standard of living and shows that since the Middle Ages there has been a regular increase in wages and purchasing power, as technology and productive capacity developed. It reveals certain little-known aspects of poverty among the masses before the industrial revolution of the eighteenth century. The second part relates to the way of life of contemporary societies; professional life and the length of working hours; education and leisure of young people; family life; evolution of health and longevity. The net result of the technical progress thus achieved is distinctly encouraging.

412 GILFILLAN, S. C. *The Sociology of Invention.* Follett, Chicago, 1935, 185 pp.

A fundamentally new discussion of the structure of inventions and their life. Most important for the evaluation of the impact of technology on society, as it destroys many fallacies on this subject.

413 GILLFILLAN, S. C. "Invention as a Factor in Economic History." *Journal of the Patent Office Society,* Washington, 1947, pp. 262-88.

Invention or technological change does not dominate economic life and hence history. The rise of civilization runs parallel to the rise of inventions, but the first has been known to decline whilst the second went on. New things generally require new tools and new techniques, new means, that is, new inventions, called forth by the social desire for them and vice versa; the inventions will affect the desires, wealth, commerce and other non-technic aspects of civilization in general.

414 HARRISON, H. S. "Analysis and Factors of invention." *Man.* London, Vol. 26, 1926, pp. 117-21, 154-58; Vol. 27, 1927, pp. 43-47.

Fundamental essays on obstrusive, directional and independent inventions and their variations and mutations. They include discussion of the factors, such as economical and sociological needs, that contribute towards the search for new techniques.

415 LEROI-GOURHAN, André. *Evolution et techniques.* Albin Michel, Paris, 2 vols. 1943/1945, 367 and 512 pp.

A new and stimulating approach to the evolution of tools and techniques, based on an extensive investigation of ethnological data. No historian of technology should fail to study this book, however doubtful some of its theories may be owing to oversystematization of historical data. It should add much to our knowledge of the diffusion and invention of primary tools and techniques.

416 MUMFORD, Lewis. *Technique et civilisation,* translated from the American edition by Denise Moutonnier (Collection "Esprit"), Editions du Seuil, Paris, 1950, 415 pp., XV pl., ample bibliography.

(French translation of work No. 62 published in *Impact* No. 1.)

417 PRAUS, A. A. "Mechanical Principles involved in Primitive Tools and those of the Machine Age." *Isis,* Brussels, Vol. 38, 1947, pp. 157-59.

The author enumerates the mechanical principles evolved up to the Iron Age and points out that the fundamental difference between their application then and in the Machine Age consists in the fact that we now apply specific natural forces and refinements of the old techniques that were then used with less discrimination.

418 SARTON, G. *Introduction to the History of Science.* Williams & Wilkins, Baltimore, 5 parts, 3 vols, 1927/1947, 839, 1251 and 2155 pp.

The most comprehensive encyclopaedia of data of the history of science and technology up to the fifteenth century A.D. Its division in chronological periods, each opened by a general cultural survey of the period, will provide the historian of technology with many pointers on the background of the period he is dealing with. The carefully selected and presented data form a real treasure-trove for any student of the development of early technology.

419 SARTON, G. *The Study of the History of Science.* Harvard, University Press, Cambridge, Mass., 1936, 75 pp.

The best guide for the future historian of technology, introducing him to the methods, reference books, periodicals and other information essential to his work. It stresses the fact that history of science (and technology) forms part of the history of civilization and therefore requires at least some historical training apart from technological knowledge.

420 SAYCE, R. U. *Primitive Arts and Crafts.* Cambridge University Press, 1933, 291 pp.

This "introduction to the study of material culture" provides an excellent survey of technology in primitive cultures, diffusion and spontaneity of invention, problems of variation and mutation, of discovery and invention, and so forth, and their connexion with spiritual life and environment.

421 SCHUHL, Pierre-Maxime. *Machinisme et philosophie.* "Nouvelle Encyclopédie philosophique." Series arranged by H. Delacroix, No. 16. F. Alcan, Paris, 1938, 16mo, 1-110 pp.

Mechanism and its relations with philosophic thought, considered in historical perspective. Premechanistic mentality of the Greeks and Romans. The birth of a new mentality at the end of the Middle Ages (Bacon and Descartes). The origins of large-scale industry and the eighteenth century. Influence of a varying nature, on the thinkers of the nineteenth century: Saint-Simon, Robert Owen, Fourier, Sismondi, Carlyle, Proudhon, Marx, etc. Numerous bibliographical references.

422 SINGER, Ch. *A Short History of Science.* Oxford University Press, London, 1946, 399 pp.

The best short history of science to be read by the historian of technology, whose field it often deals with as a sideline of the history of science.

423 TAYLOR, F. Sherwood. *Science, Past and Present.* London, 1945, 320 pp.

An excellent short history of science, giving many extracts from the original works. Will serve the historian of technology well as a background to his subject.

424 USHER, A. P. *History of Mechanical Invention.* New York, 1929, 320 pp.

A good history of technology, but deficient in data on technology in Antiquity. Nor does it give any consideration to the background of technology. It is, however, very useful, as the treatment of the technological subjects is very accurate and clear.

425. VOWLES, Hugh P. and Margaret W. *The Quest for Power.* Chapman & Hall, London, 1931, 354 pp.

Though somewhat dully written, this book provides the only continuous history of mechanical power machinery "from prehistoric times to the present day". It can be used with profit as an introduction to the subject, though standard handbooks should be consulted on details. The social and economic effect of power engines is discussed in a general manner only.
See also abstract No. 246 in *Impact*, Vol. I, No. 3-4, 1950.

COLLECTIVE WORKS

426 *L'homme, la technique et la nature*, by Jean CASSOU, Georges FRIEDMANN, Luc DURTAIN, Marc BLOCH, Jean LUC, André VARAGNAC, etc. Preface by Jean Cassou, (Collection "Europe"). Rieder, Paris, 1938 (30 January 1939), 359 pp.

While the middle-class order is rapidly approaching its end, a new civilization based on new techniques is being born. This book, in which are assembled a series of articles published in "Europe" (Nos. 185, 186, 187 and 188 in the issues of 15 May, 15 June, 15 July and 15 August 1938), attempts to analyse certain aspects of this new civilization as seen by historians, scientists, sociologists, authors, artists and poets. Of these articles, special mention may be made of the following:

FRIEDMANN, Georges. *Esquisse de quelques problèmes*, pp. 11-24.
BLOCH, Marc. *Technique et évolution sociale. Réflexions d'un historien*, pp. 29-33.
LUC, Jean. *Techniques intellectuelles et culture générale*, pp. 38-50.
VARAGNAC, A. *L'homme et les techniques prémachinistes*, pp. 51-57.
ZORETTI, Ludovic. *Culture et métier*, pp. 58-66.
CHERONNET, Louis. *Bilan de l'exposition*, pp. 67-96 (the exhibition concerned is the World Exhibition of 1937).
LE CORBUSIER. *Espoir de la civilisation machiniste.* Le logis, pp. 97-[illegible]4.
SPIRE, André. *Pour la technique*, pp. 196-212.

Numerous other articles deal with the relations between technology on the one hand and art, music, the theatre, language, sport, medicine and education on the other.

427 *Progrès technique et progrès moral*, by André SIEGFRIED, Nicolas BERDIAEFF, Emmanuel MOUNIER, Eugénio d'ORS, SIDDHESWARANANDA, Marcel PRENANT, etc. (Texts of lectures and talks organized by the Rencontres Internationales de Genève in 1947). Neufchâtel, éditions de la Baconnière; O. Zeluck, Paris, 1948, 8 vols, 488 pp.

Special mention may be made of the following lectures:

SIEGFRIED, André. *Historique de la notion de progrès*, pp. 9-22.
PRENANT, Marcel. *Le progrès humain vu par un biologiste*, pp. 23-47.
BERDIAEFF, Nicolas. *L'homme dans la civilisation technique*, pp. 69-89.

HALDANE, J. B. S. *Influence du progrès technique sur le progrès moral*, pp. 91-111.

Swami SIDDHESWARANANDA. *La conscience humaine et l'angoisse de la civilisation*, pp. 155-80.

MOUNIER Emmanuel. *Le christianisme et l'idée de progrès*, pp. 181-223.

These texts are followed by the talks and discussions which took place at this *Rencontre internationale* and in which the lecturers and various personalities took part (pp. 225-85). G. Ganguilhem has published an article on the *rencontre* in the *Année sociologique*, 3rd series, 1940-48, Vol. II, pp. 785-91.

428 *Le travail et les techniques*, by I. MEYERSON, L. FEBVRE, A. AYMARD, Et. DELARUELLE, P. VIGNAUX, M. MAUSS, etc. Foreword by I. Meyerson. (Lectures given during the Journée de psychologie et d'histoire du travail et des techniques, organized by the Société d'études psychologiques of Toulouse on 23 June 1941.) *Journal de Psychologie*, No. 1, 1948 (special number), 146 pp.

The lectures may be grouped under two headings.

I. *History of the Idea of Work*

FEBVRE, Lucien. *Travail: évolution d'un mot et d'une idée*, pp. 19-28.

AYMARD, A. *L'idée de travail dans la Grèce archaïque*, pp. 29-49 (Discussions).

DELARUELLE. *Le travail dans les règles monastiques occidentales du IV^e^ au IX^e^ siècle*, pp. 51-64 (Discussions).

VIGNAUX, P. *Travail et théologie: notes en marge de Proudhon*, pp. 65-70.

II. *Techniques and the Mind*

MAUSS, Marcel. *Les techniques et la technologie*, pp. 71-78.

LALANDE, André. *Technique et science*, p. 79 (Discussion).

FAUCHER, D. *Routines et innovations dans la vie paysanne*, pp. 89-102.

BLOCH, Marc. *Les transformations des techniques comme problème de psychologie collective*, pp. 104-19 (Discussion).

CAMICHEL, Ch. *Les caractères des techniques modernes et leurs effets*, pp. 120-26 (Discussion).

FRIEDMANN, Georges. *Esquisse d'une psycho-sociologie du travail à la chaîne*, pp. 127-44.

II. *Antiquity*

429 BLUMNER, H. *Technologie und Terminologie der Gewerbe und Künste bei Griechen und Römern.* Teubner, Berlin, 4 vols. 1900, 1020 pp.

Though antiquated and in parts obsolete, this is still by far the best and most complete introduction to classical technology. It does not deal with the sociological or economic aspect of technology, but most of the information it contains is still invaluable. The first volume, dealing with baking, textiles, dyeing and painting, leather, paper and perfumes, was republished in a revised edition in 1912.

430 BREASTED, J. H. Ancient Times. Ginn & Co., Chicago, 1935, 823 pp.

Though no longer correct in certain details, this book is certainly still the most readable and instructive introduction to history up to the Middle Ages. It can be consulted with profit by the historian of technology on the background of pre-classical and classical technology.

431 BRUNET, Pierre and MIELI, Aldo, *Histoires des Sciences, I, L'Antiquité.* Payot, Paris, 1935, 1224 pp.

The only volume published of the series planned. Though deficient in information on pre-classical Antiquity it gives some excellent paragraphs on technology in Antiquity, together with extracts from important works.

432 CHAPOT, V. "Sentiment des anciens sur le machinisme." *Revues des études anciennes*, Paris, Vol. 40, 1938, pp. 158-62.

On the development of machinery to take over part or the whole of man's task. Only the first category was developed in Antiquity, as mechanical power was not available and manpower was still cheap. The personal tradition of the craftsmen was a strong force in hindering mechanization.

433 COHEN, MORRIS, R. and DRABKIN, I. E. *A Sourcebook in Greek Science.* MacGraw Hill, New York, 1948, 579 pp.

This very up-to-date and excellent sourcebook gives many important texts on ancient technology. It is provided with a good bibliography, leading the historian of science and technology to the proper sources.

434 DIJKSTERHUIS, E. J. *Maatschappelijke invloeden in de Griekse natuurwetenschappen.* Hermeneus, Groningen, Vol. 18, pp. 23-29, 1946.

The author points out that Farrington (cf. 30.)

overstresses the influence of technology on ancient Greek science, and warns the reader not to try to read modern class-contrasts into Greek society.

435 FORBES, R. J. *Bibliographia Antiqua, Philosophia Naturalis.* Nederlands Instituut voor het Nabije Oosten, Leiden, 1940, 10751 ref.

This bibliography of science and technology in Antiquity, in 10 chapters, published in several parts, is intended to present the historian of technology with sufficient titles of books and essays to enable him to undertake the study of any branch of science and technology in Antiquity. It contains the literature up to 1940: a supplement dealing with titles published between 1940 and 1950 is in the press.

436 FORBES, R. J. *Ambacht en Wetenschap in het Nabije Oosten (Oude)*, Brill, Leiden, 1947, 46 pp.

The author demonstrates the place of artisans and craftsmen in the society of the Ancient Near East. Their guilds were led by men of priestly rank and training as the religious and philosophical order of the ancient world demanded. Thus in pre-classical Antiquity there was unity between technology and what was then understood to be science, the observation of nature and the place of natural objects in the world order.

437 FORBES, R. J. "Man and Matter in the Ancient Near East." *Archives internationales d'histoire des sciences*, Vol. I, 1948, pp. 557-73.

The author argues that there was a close contact between the "craftsmen" and those "scientists" of priestly training who headed the guilds and who classified the data of the craftsmen into the order of Nature as conceived by pre-classical civilizations. The disrupture of the crafts and their spiritual leaders caused the gap between technology and science which broadened in Classical Antiquity.

438 FORBES, R J. "The Ancients and the Machine." *Archives internationales d'histoire des sciences*, No. 8, 1949, pp. 919-33.

The author enumerates various social, economical, technical and spiritual factors that impeded the development of the machine in Classical Antiquity, which was scientifically and technically fully prepared to develop it. One of the great changes which hastened the introduction of machinery was the advent of Christianity with its doctrine of equality of men, combating the views of the ancient ruling castes which looked down on the craftsmen and on labour in general. Christianity, by stripping natural forces from their earlier magical content, provided the basis for their practical harnessing for the benefit of mankind.

439 FORBES, R. J. "Professions and Crafts in Ancient Egypt." *Archives internationales d'histoire des sciences*, No. 12, 1950, pp. 599-618.

Ancient Egyptian texts prove the multiplicity and specialization of crafts in the ancient river valley civilizations of the Near East. The texts also demonstrate the fact that slaves played but a minor part in the production process, and that the craftsmen were free artisans from the earliest period until Roman times.

440 FRANK, T. (ed.) *An Economic Survey of Ancient Rome.* John Hopkins Press, Baltimore, 6 vols., 1933/1940, respectively 431, 732, 664, 950, 445 and 140 pp.

This most important collection of economic data on Republican and Imperial Rome contains very valuable material for the historian of technology. As the texts are quoted in full, material that is not easily available is here presented in a handy form for further use.

441 GARROD, D. A. E. *Environment, Tools and Man.* The University Press, Cambridge (Eng.), 1946, 160 pp.

An excellent study of the technical development of the Stone Age and the factors that, given the scarce evidential data, can be said to have played a part in that development.

442 GEST, A. P. *Engineering.* Series "Our Debt to Greece and Rome". Harrap, London, 1930, 221 pp.

Still one of the best summaries of classical engineering to be used as an introduction to this field by the historian of technology.

443 GIRAUD, Paul. *La main-d'œuvre industrielle dans l'ancienne Grèce.* Paris, 1900, 242 pp.

An account of the place of technology in ancient Greek society which, though antiquated, still contains very valuable data.

444 GLANVILLE, S. R. K. *Legacy of Egypt.* The Clarendon Press, Oxford, 1942, 424 pp., Bibliography.

This book contains the only up-to-date condensed discussion of the achievements of the ancient Egyptians in engineering and technology.

445 GLOTZ, G. *Ancient Greece at Work.* Kegan Paul, Trench, Trubner & Co., London, 1925, 400 pp.

A good economic history of ancient Greece in which the reader will find many reliable data on the position of technology in ancient society.

446 GOEGHAGAN, A. T. *The Attitude towards Labor in early Christianity and ancient Culture.* Catholic University of Mareica Press, Washington, 1945, 250 pp.

An important summary of the evidence found in ancient literature on the place of labour and technology in classical Antiquity up to the end of the Roman Empire. The change of attitude through the Christianization of the Mediterranean world is clearly demonstrated.

447 LAMER, H. *Wörterbuch der Antike.* Kröner, Leipzig, 1936, 892 pp.

This little encyclopaedia of classical antiquities takes particular care to mention those techniques and technologies that date back to classical Antiquity and that survive in modern civilization. The book contains some very interesting data on ancient technology and the background of that technology is not forgotten.

448 MENDELSOHN, I. *Slavery in the Ancient Near East.* Oxford University Press, New York, 1949, 162 pp.

An important collection of texts on slavery in the Ancient Near East, which proves the difference between the popular idea of the ancient slave and the true status of the "bondsman" in ancient society. The author demonstrates the minor part that true slaves

played in industrial production, which fell largely in the free artisan and craftsman. Important for the knowledge of the atmosphere in which ancient technology developed.

449 MICHELL, H., *The Economics of Ancient Greece.* Cambridge University Press, New York, 1940, 415 pp.

The mos up-to-date description of technology, economics and society in classical Greece, which, however, is not quite complete on the technological side.

450 OERTEL, F. *Zur Frage der attischen Grossindustrie.* Rheinisches Museum, 1940, pp. 230-52.

Important study on the extent of industrialization of ancient Greece. The workshop of the single craftsman with a few helpers dominated. "Manufactures" or *"ergasteria"* of up to 30 craftsmen did exist, but they never dominated and did not extend as profits were always withdrawn from the production process.

451 PEAKE, H. *Early Steps in Human Progress.* Sampson Low, Marston & Co., London, 1932, 256 pp.

A good popular discussion on the development of arts and crafts in pre-classical times. Fire, tools, husbandry and farming implements, the earliest mills, housebuilding, pottery, textiles, transport, writing, metallurgy and weapons are discussed.

452 REHM, A. "Zur Rolle der Technik in der griechisch-römischen Antike." *Archiv für Kulturgeschichte,* Vol. 28, 1938, pp. 135-62.

The author comments on the neglect of classical technology by classical scholars and mentions several outstanding achievements. The facts given show that "cheap slaves", which in reality represented an expensive form of labour, could never, except in State-sponsored industries, oust the free craftsman, who, as the centuries passed by, gained in social status. But no planning of industry and no furthering of applied science can be detected, and progress by trial and error was slow.

453 ROSTOVTZEFF, M. *Gesellschaft und Wirtschaft im Römischen Kaiserreich.* Quelle und Meyer, Leipzig, 2 vols., 1930, 348 and 422 pp.

This economic and social history of the Roman Empire contains many important facts regarding the development of technology and industry during the period. As the papyri and other new sources have been tapped, it makes valuable additions to the older compilations on Roman technology.

454 ROSTOVTZEFF, M. *The Social and Economic History of the Hellenistic World.* Clarendon Press, Oxford, 3 vols., 1941, 1779 pp.

This standard work on the subject contains many new data from papyri and other sources which go to complete the evidence collected in older textbooks on ancient technology. As the economic and social forces are discussed in great detail, this work will serve as a basis for future studies on ancient technology of the period.

455 SALANT, W. "Science and Society in Ancient Rome." *Science Monthly,* Vol. 47, 1948, pp. 525-35.

Contrary to common opinion, ancient Rome shows a remarkable paucity of inventions, and the Romans profited but little from their contact with the Greeks and the outer world. The leading classes, thriving on their slave-worked latifundia, were not interested in technology, which throve only when the State took it in hand, e.g., public works, war engines, etc. Technology of free craftsmen could not prosper in the totalitarian State of the Later Roman Empire.

456 SPEISER, E. A. "Ancient Mesopotamia and the Beginnings of Science." *Nature,* London, Vol. 146, 1940, pp. 705-09.

The author contrasts the social background of Egyptian and Mesopotamian science. His conclusions are important also for the technology developed in both countries.

457 TORREY, H. B. "The Evolution of Mechanical Ideas in Ancient Greek Thought." *American Naturalist,* New York, Vol. 72, 1938, pp. 293-303.

On the influence of practical machinery and mechanism on the theories and cosmologies of the early Greek philosophers.

458 TURNER, Ralph. *The Great Cultural Traditions.* MacGraw Hill, New York, 2 vols., 1941, 1333 pp.

This history of the development of social order in the ancient civilizations, Asia and the Far East up to about A.D. 500 will serve well as an introduction to the background of ancient technology.

459 WESTERMANN, W. L. "Industrial Slavery in Roman Italy." *Journal of Economic History,* New York, Vol. 2, 1942, pp. 149-63.

Extensive study of the part played by the slave in Roman industry. "A fundamental connexion may be established between the amelioration of slave conditions and the industrializing of slave and freed-man employment. Urban slavery, whether in domestic or in craft employment, tends to soften the master's attitude towards the enslaved. Christianity only accelerated the crumbling of social walls which long before had begun to level down; the daily practice of urban life made the more humane theory of Stoicism possible as well as the kindlier practice of early Christianity."

460 WRIGHT, F. Warren. "Roman Factories." *The Classical Weekly,* New York, Vol. 11, 1917, pp. 17-19.

The author discusses the forms of factories known to have existed in the Roman Empire. The "lack of mechanical means for the production of power seems the chief reason why the Roman *officinæ* did not correspond exactly to our factories, whose growth has been conditioned and accompanied by the development of high-power engines and high-power machinery". But Roman workshop products retained their own individuality.

III. *The Middle Ages, their Roots and the Rise of Applied Science*

461 ARNOLD, Sir Thomas and GUILLAUME, Alfred. *The Legacy of Islam.* Oxford University Press, 1945, 416 pp.

This cultural survey of the achievements of Arab civilization contains the only summary embracing science and technology of the period, by Meyerhof. Other fragments are found in the volume by Mez (cf. 77). Most of the information on technology of this period is spread over articles in many periodicals and is difficult to get at. This survey will also serve admirably for the study of the background of Arabic technology.

462 BLOCH, Marc. "Avènement et conquête du moulin à eau." *Annales d'histoire économique et sociale,* Paris, Vol. 7, 1935, pp. 538-63.

Important study on the introduction of the water-wheel as the machinery for flour production, and its penetration into the West. The consequences upon the mechanization of other industries, such as metallurgy, are discussed.

463 BOISSONNADA, P. *Life and Work in Medieval Europe,* Kegan Paul, Trench & Trubner, *London,* 1927, 395 pp.

Though in certain parts antiquated, this is the only reliable survey of medieval technology from the fifth to the fifteenth century extant. It deals with the social and economic background of the Middle Ages too, but the technological part is rather weak and many gaps remain to be filled up by future historians of technology.

464 BORKENAU, Franz. *Der Uebergang vom feudalen zum bürgerlichen Weltbild, Studien zur Geschichte der Manufacturperiode.* F. Alcan, Paris, 1934, 450 pp.

Borkenau believes that the "manufactures", the characteristic forms of technology and factories of the eighteenth century, date back much further and can be traced already in the early fifteenth and sixteenth centuries. His views were strongly criticized by Grossmann (cf. 72).

465 BRATIANU, G. I. *Etudes byzantines d'histoire économique et sociale.* Paul Geuthner, Paris, 1938, 292 pp.

Data on Byzantine technology are extremely difficult to get, as they appear scattered over many specialist periodicals. This book contains many valuable data, especially on the status and development of agricultural techniques in the Byzantine Empire.

466 CARUS-WILSON, E. M. "An Industrial Revolution of the Thirteenth Century." *Economic History Review,* London, Vol. 11, 1941, pp. 39-60.

A close study of the nascent cloth industry of England in the thirteenth century does not show the decline usually reported. This period witnessed, in fact, "an industrial revolution due to scientific discovery and changes in technique; a revolution that brought poverty, unemployment and discontent to certain old centres of the industry, but wealth, opportunity and prosperity to the country as a whole, and which was destined to alter the face of medieval England".

467 CLAPHAM, J. H. and POWER, E. *The Cambridge Economic History of Europe.* The University Press, Cambridge (Eng.), Vol. I, 1942, 650 pp.

This first and only volume of the Cambridge Economic History of Europe yet published deals with the agrarian life of the Middle Ages and contains very important and sound information on the development of agrarian techniques and implements during this period. The second volume will discuss urban, commercial and industrial life in the Middle Ages.

468 COULTON, C. G. *Medieval Panorama.* The Mac Millian Company, New York and Cambridge (Eng.), The University Press, 1938, 801 pp.

An excellent survey of medieval life in all its aspects, which will provide the historian of technology with a good background. Though medieval science with its problems is discussed at some length, the book contains only scattered information on medieval technology.

469 DIJKSTERHUIS, E. J. *De mechanisering van het wereldbeeld.* Meulenhoff, Amsterdam, 1950, 590 pp.

Though mainly a story of mechanics and the rise of the mechanistic world-system from the Greeks to Newton, this book discusses the influence of technology and machines on scientific theories both in the classical period and in the later Middle Ages. Most important for its discussion of medieval scientific thought.

470 DURAND, Dana B. "Tradition and Innovation in Fifteenth-Century Italy." *Journal of the History of Ideas,* New York, Vol. 4, 1943, pp. 1-40.

The author proves that "the balance of tradition and innovation in fifteenth-century Italy was not so decisively favourable as to distinguish that century radically from those that preceded it, nor to constitue the *Quattrocento* a unique and unrivalled monument in the history of western thought". Both in science and in technology the Renaissance is not unique in spontaneity, but is the continuation of threads going back into the Middle Ages proper.

471 GROSSMANN, H. "Die Gesellschaftlichen Grundlagen der mechanistischen Philosophie und die Manufaktur." *Zeitschrift für Sozialforschung,* Vol. 4, 1935, pp. 161-231.

Severe criticism of Borkenau's theories on the early date of the "manufacture" form of industry. Though technology shows some typical forms of the later

mass-industry in early capitalistic times, the true "manufactures" date from the late seventeenth and early eighteenth centuries only.

472 HESSEN, B. "The Social and Economic Roots of Newton's Principia." *Science at the Cross Roads*, by Bukharin *et al.*, Kniga, London, 1931, 240 pp.

The author attempts to show that the science of Newton, which represents the culmination of sixteenth and seventeenth-century mechanics and astronomy, is the outcome of the economic needs of the rising commerce and capitalism. Newton's work is the answer to the technological problems arising from these economic developments. This work is highly controversial in nature (cf. 101).

473 MEZ, A. *Die Renaissance des Islâms*. Carl Winter, Heidelberg, 1922, 492 pp.

This older book on Arab civilization at its apex is still valuable for its survey of technology, which presents data not to be found in other books. This chapter outlines some of the economic conditions that led to the rise of the gold industry, coal mining, silk industry, jewellery and many other trades.

474 NEF, J. U. "The Progress of Technology and the Growth of Large-Scale Industry in Great Britain, 1540-1640." *Economic History Review*, London, Vol. 5, 1934/1935, pp. 3-24.

The author demonstrates that as the social revolutions accompanying the rise of capitalism were both earlier and more gradual in Great Britain than else where the "Industrial Revolution" (1760-1832) was not a sudden phenomenon, but was in all probability more continuous in that country than in any other. The contrast between industrial progress in England and in continental countries was particularly striking in the two centuries preceding the Industrial Revolution.

475 ORNSTEIN, M. *The Role of Scientific Societies in the Seventeenth Century*. University of Chicago Press, Chicago, 1938, 308 pp.

Technology, and more especially its phase of transformation into applied science, cannot be properly studied without acknowledgement of the part which the learned societies of the seventeenth century (and later) played in formulating practical problems in scientific language and disseminating the results of exact and applied science throughout the western world.

476 PARSONS, W. B. *Engineers and Engineering in the Renaissance*. Williams & Wilkins, Baltimore, 1939, 661 pp.

After surveying the spiritual background of the period, the author gives a series of essays on the invention and application of machines, mining, municipal and governmental engineering, hydraulic and structural engineering, mainly in Italy and France. This detailed study of Renaissance engineering is the most reliable book on the period.

477 STIMSON, D. *Scientists and Amateurs*. Schuman, New York, 1948, 267 pp.

This history of the Royal Society is most valuable as a study of the very practical goal which this learned body set itself in its charter, and the way in which it succeeded in stimulating research in applied science in fields such as navigation, agriculture, mining, etc., during the various periods of its life.

478 THEOBALD, W. *Technik des Kunsthandwerks im Zehnten Jahrhundert*. V.D.I. Verlag, Berlin, 1933, 553 pp.

This edition of parts of the *Diversarium Artium Schedula* by Theophilus the Priest is most important for our knowledge of early medieval technology such as metallurgy, jeweller's craft, glass-making, etc. The copious notes by the editor and the many drawings to illustrate these notes will considerably help the historian of technology.

479 WHITE, Lynn. "Technology and Invention in the Middle Ages." *Speculum*, New York, Vol. 15, 1940, pp. 141-59.

The author has carefully enumerated and evaluated the inventions to be attributed to the Dark Ages and the Middle Ages. "The study of medieval technology is far more than an aspect of economic history; it reveals a chapter in the conquest of freedom. Latin Middle Ages first discovered the dignity and spiritual value of labor, that to labor is to pray. They gradually and very slowly began to explore the practical implications of an essentially Christian paradox; that just as the heavenly Jerusalem contains no temple, so the goal of labor is to end labor".

480 WOLF, A. "A History of Science, Technology and Philosophy. Sixteenth and Seventeenth Centuries." George Allen & Unwin, Ltd., London, 1935, 692 pp.

A very useful survey of science and philosophy of the period though rather weak in technology. However, this remains the best survey in this field, and it is most useful for the study of the philosophical background of technology in these centuries and the gradual symbiosis of technology and science.

IV. *The Industrial Revolution and its Aftermath*

481 ASHTON, T. S. *The Industrial Revolution*, 1760-1830. Oxford University Press, 1948, 167 pp.

This is by far the best concise history of the Industrial Revolution. The author's grasp of the real technological innovations of this period and the excellent way in which he deals with its economy, enable him to correct the common belief that the Industrial Revolution meant nothing but the ruin of thousands of workers in the new factories. Sticking to the actual historical evidence, he demonstrates that this Industrial Revolution was a boon to England as a whole, though it may have had bad effects on certain groups of the population locally and during certain periods only.

482 BIRNIE, Arthur. *An Economic History of Europe, 1750-1939.* Methuen & Co., Ltd., London, Fourth edit., 1944, 277 pp.

This concise introduction to economic history since the Industrial Revolution provides arguments and data for the study of the phases of the rise of modern technology and its consequences.

483 CLARK, G. N. *The Seventeenth Century.* Oxford University Press, London, 1947, 378 pp.

An excellent history of European civilization of the seventeenth century, in which the part of science and technology is described without going into great detail. This book will serve as a good introduction to the part played by technology in this period.

484 CRESSY, E. *A Hundred Years of Mechanical Engineering.* The Macmillan Company, New York, 1937, 250 pp.

This is the only satisfactory history of mechanical engineering in the past century, valuable for the full information it contains. It is not written as a sociological study but purely as a history of the technical evolution of this branch of engineering.

485 DUPLESSY, Lucien. *La machine ou l'homme.* Collection "La Colombe". Editions du Vieux-Colombier, Paris, 1947, 222 pp.

A study of contradictions in the modern world and the effects of mechanization on contemporary civilizations. Disastrous consequences, spiritually, morally and aesthetically, of ultra-industrialization and the mechanization of labour. Search for solutions and remedies, which should be directed mainly towards reforming the conscience of mankind.

486 FOURASTIÉ, Jean. *La civilisation de 1960.* Presses universitaires de France, Paris, 1947, 118 pp.

A study of the technical progress accomplished since the Industrial Revolution of 1830, and of the social changes accompanying it (improvement of the standard of life, increase of leisure time, improvement of health conditions, increase of the average span of life, etc.). The whole study is based on precise facts that can be expressed in figures (salaries, prices, output, etc.), thus enabling not only statistics and graphs to be compiled, but also certain forecasts of future developments.

487 FRIEDMANN, Georges. *Machine et humanisme. II. Problèmes humains du machinisme industriel.* Gallimard, Paris, 1946, 389 pp.

A study of the physiological and psychological factors involved in mechanized work and an attempt to suggest possible improvements. Technical progress has considerably improved things for the consumer; but, in a great many cases, the life of man as producer has lost all significance. Various remedies are possible, mostly in the psycho-sociological field (the humanizing of work, the raising of the technical worker's cultural level, the broadening of his outlook, the renewing of human relations, etc.). A work that goes to the root of the problem.

488 FRIEDMANN, Georges. *Histoire de la civilisation: époque contemporaine.* IX[e] Congrès international des sciences historiques, rapports, Paris, 1950, pp. 367-81.

A general survey of the psycho-physiological conditions governing the lives of men in the new environment created by technical progress; the birth of a new civilization.

489 FRIEDMANN, Georges. *Où va le travail humain?* Editions N.R.F., Paris, 1950, 389 pp.

Mechanization is creating a new civilization which cuts men off from their natural surroundings and incorporates them into an inhuman world of technique. The result is that the worker loses his personality. His life is determined by the rhythm of chain-production; he is condemned to fragmentary tasks. He loses his creative sense. Human life revolves around technology, and man has been reduced to an instrument for controlling machines.

It is this fundamental and alarming problem of our times that Georges Friedmann considers: Is the Earth escaping from Man's control and becoming the scene of a mechanical drama and, if so, what part can Man play but that of an impotent robot? There can be no question of turning back the clock; but instead of enslaving Man, could not the new industrial civilization, on the contrary, set him free and give him greater chances of happiness? The author takes most of his examples from life in America, where industrialization and mechanization have progressed more than in any other country in the world.

490 GIRVIN, Harvey F. *An Historical Appraisal of Mechanics.* International Textbook Co., Scranton (Pa.), 1948, 275 pp.

This book studies the impact of the evolution of the science of mechanics on the engineering craft and its possibilities. Though the earlier parts should be carefully checked with the original documents and

do not always reproduce the ancient theories correctly, the chapters dealing with the last three centuries are very stimulating for those who wish to assess the role of mechanical and civil engineering as a science applying the achievements of theoretical mechanics.

491 GOLDENWIESER, Alexander A. *Robots or Gods; an Essay on Craft and Mind.* Knopf, New York, 1931, 240 pp.

A thought-provoking book on the part played by technology in modern society.

492 HAMILTON, Henry. *History of the Homeland,* George Allen & Unwin, Ltd., London, 1947, 597 pp.

This "Story of the British Background" can be described as a popular history of the social and economic implications of the Industrial Revolution, with some excursions into the roots of this phenomenon. Though written from a particular point of view and in places dogmatic, this book is worth consulting for its excellent graphs and illustrations, which provide valuable data for further study of the problem of modern industry and society.

493 HAMMOND, J. L. and B. *The Rise of Modern Industry.* New York, 1926, 300 pp.

A very readable account of the growth of modern industry and technology, useful for consultation purposes as it contains valuable data.

494 HATFIELD, H. Stafford. *The Inventor and his World.* Penguin Books, Ltd. Harmondsworth, 1948, 256 pp.

A thorough and stimulating discussion of the role of the inventor in the modern world, the factors playing a part in inventions and the types of invention in different fields of knowledge.

495 HEATON, Herbert. *Economic History of Europe.* Harper & Brothers, London, 1936, 775 pp.

This is primarily an economic history of Europe, but is especially valuable for the study of the impact of technology on economy in the last four centuries, as it shows the rapidly increasing influence which technology obtained in those centuries through mechanization and discusses the commercial organization of modern industry concisely and clearly.

496 HOWLAND, W. E. *The concept of Engineering; a Development of the Eighteenth Century.* Civil Engineering, New York, Vol. 10, 1950, 711-14 pp.

The author contrasts the State-forstered engineering education of eighteenth-century France with the generation of practical engineers that "just grew" in England, and details some of the sociological background of this development.

497 KIRBY, R S. and LAURSON, P. G. *The Early Years of Modern Civil Engineering.* Yale University Press, New-Haven (Conn.), 1932, 324 pp.

This is the only concise history of modern civil engineering and its branches from the Renaissance onwards. Its bibliographies are important sources for further study.

498 MANTOUX, P. *The Industrial Revolution in the Eighteenth Century.* Jonathan Cape, London, 1947, 539 pp.

This eighth impression of a handbook on the Industrial Revolution which was written 40 years ago is still well-worth consulting for its painstaking compilation of data and notes and the constant care taken to point out the social and economic consequences of the changes in technology in eighteenth-century England.

499 MÉNÉTRIER, Jacques. *La vie collective.* Collection "Présences". Plon, Paris, 1947, 343 pp.

An analysis of the present-day world centred on the relationship between the human personality and its resources shows that, from the moral and material standpoint, Western society will soon have to establish itself on a "collective" basis, in accordance with the facts and requirements of life. The civilization which man has built up is such that the individual can no longer act except to his own detriment. The progress of technology and science, the increase of mechanization, etc., have given rise to an extension of industrial civilization that has reduced the worker to the level of the machine. The individual in Western society has unlimited *means* of action at his disposal, but his *field* of action is being gradually restricted by the development of other personalities and the increasing number of organizations. Man must find a new way of life enabling him to remain a "man" while utilizing all the tools which his intelligence has permitted him to contrive. The object of this study is to try to discover a new mode of life which involves neither unbridled egoism nor complete submission to the power of the "group". This leads it to define, by way of conclusion, a form of collectivism based alike on technique and "mysticism".

The author, who is a doctor and uses a biological method for analysing man and existence puts forward a number of considerations concerning the modern world and its future possibilities.

500 MERTON, R. K. "Fluctuations in the Rate of Industrial Invention." *Quarterly Journal of Economics.* Washington, Vol. 49, 1935, pp. 454-74.

A statistical study of the socio-economic problems of rates of invention and shifts of inventive interest during the last century. Important are the progressive limitation of continued invention within a restricted field, the economic factors in realizing the invention, the shift of attention and possibility of profit by new inventions. This paper contains very valuable material completing the suggestions made by Gilfillan (cf. 5 and 7).

501 OEHSER, P. H. *Sons of Science.* Schuman, New York, 1949, 262 pp.

This story of the Smithsonian Institution and its leaders forms an instructive example of how scientific research gradually claims its place in our modern civilization and how planned research is applied to the furthering of science and technology.

502 PARSONS, R. H. *The Early Days of the Power Station Industry.* Cambridge University Press, 1940, 217 pp.

This excellent book is the best introduction to the technical development and consequences of power generation on a large scale as life-juice of modern industry. Though the sociology of the power station is not the concern of the author, the pages contain many indications valuable to the sociologist.

503 PLEDGE, H. T. *Science since 1500.* H.M. Stationery Office, London, 1939, 357 pp.

This is by far the best condensation of the history of science during the last four centuries. As this is the critical period in which science and technology merged to turn technology into applied science, this book can be consulted with profit on the impulses in the background of technical advance and on the way in which science profited from this merge.

504 RANDALL, J. H. *The Making of the Modern Mind.* Houghton Mifflin & Co., Boston, 1940, 696 pp.

Important well-documented survey of the intellectual background of European civilization since the Middle Ages.

505 RENARD, G. and WEULERSSE, G. *Life and Work in Modern Europe.* Kegan Paul, Trench & Trubner, London, 1926, 895 pp.

This survey of the history of technology and its economic and social background in the fifteenth to eighteenth centuries is one of the older books on the subject, but is still well worth reading, as no other and more modern book covers the whole of Europe so well.

506 ROMAINS, Jules. *Le problème numéro 1.* Plon, Paris, 1948, 230 pp.

This problem is that of the bewilderment of modern man in the presence of the material and moral problems created by the Industrial Revolution and technical progress. Whereas the latter is proceeding at an ever-increasing rate, institutions are evolving very slowly and not always in the direction of progress, and human nature remains unchanged. There is an increasing lack of balance between these three factors, which accounts for the ever more sudden catastrophes that are characteristic of our age.

507 SIEGFRIED, André. *Technique et culture dans la civilisation moderne.* Centre de perfectionnement technique et administratif du chemin de fer métropolitain, Paris, 1948, 19 pp.

A study of the often disastrous effects of modern technical progress on the traditions of our "Greco-Christian" civilization, and on the freedom and culture of the individual.

508 STRAUB, Hans. *Die Geschichte der Bauingenieurskunst.* Birkhäuser, Basel, 1949, 285 pp.

This history of civil engineering tries to explain the links of the evolution of canal, bridge, dam, and harbour building with the science of mechanics and the history of civilization in general. Great attention is given to the consequences of the introduction of new construction materials, such as cast iron and cast steel, and the mechanization in many fields of civil engineering.

509 THORNTON, J. E. (ed.) *Science and Social Change.* The Brookings Institute, Washington, 1939, 577 pp.

Though this selection of passages from important modern authors deals primarily with the social implications of science, it not only contains chapters on invention and industrialism but has a section (part III) devoted to the economic and social accompaniments of technology, the significance of mechanization, cycles and depressions and social trends. It is therefore valuable as an introduction to the impact of modern technology on society in general.

510 UCCELLI, A. *Storia della Tecnica dal Medio Evo ai Nostri Giorni.* Ulrico Hoepli, Milan, 1945, 933 pp.

This is the most profusely illustrated history of modern technology from the Middle Ages onwards. Though somewhat uncritical in details and lacking proper discussion of sociological and economic background this book is a mine of information on the history of mechanical engineering, metallurgy, textiles, military techniques, naval construction, roads and bridges, architecture and civil engineering.

511 WOLF, A. *History of Science, Technology and Philosophy, Eighteenth Century.* George Allen & Unwin, London, 1938, 814 pp.

An admirable condensed introduction to the subject, which is still valuable though the technology part is not the best of the book. It still serves well for the study of the intellectual and scientific background of eighteenth-century technology.

COLLECTIVE WORKS

512 *Industrialisation et technocratie,* Lectures by M. BYE, Ch. BETTELHEIM, J. FOURASTIÉ, G. FRIEDMANN, G. GURVITCH, E. C. HUGHES, etc. Collection published under the direction of Georges Gurvitch. Introduction by Lucien Febvre (First Sociological Week organized by the Centres d'études sociologiques de l'Ecole pratique des hautes études, 6th section). A. Colin, Paris, 1949, XIII, 214 pp.

The lectures in question and the discussions to which they gave rise related more often to the problems of techno-bureaucracy than to those of industrialization.

MOUNIER, E. *La machine en accusation, aux origines psycho-sociales de l'anti-technicisme,* pp. 1-22. This lecture was published by the Editions du Seuil in 1949 under the title of *"La petite peur de XX^e siècle".*

HUGHES, Everett C. *Les recherches américaines sur les relations industrielles,* pp. 23-36 (Discussion).

FOURASTIÉ, Jean. *Technocratie et rendement économique,* pp. 37-42.

FRIEDMANN, Georges. *La technocratie et la civilisation technicienne,* pp. 43-62 (Discussion).

BYÉ, Maurice. *Vers un quatrième pouvoir?* pp. 63-83 (Discussion).

BETTELHEIM, Charles. *Les techniciens constituent-ils une classe sociale?* pp. 84-100 (Discussion).

VERNANT, Jacques. *Evolution technique et structure sociale,* pp. 101-17 (Discussion).

LEFEBVRE, Henri. *Les conditions sociales de l'industrialisation,* pp. 118-42 (Discussion).

LASKI, Harold I. *L'état, l'ouvrier et le technicien,* pp. 143-66 (Discussion).

VARAGNAC, André. *Industrialisation et expérimentation sociale,* pp. 167-78 (Discussion).

GURVITCH, Georges. *La technocratie est-elle un effet inévitable de l'industrialisation?* pp. 178-99.

AUTHOR INDEX

(The figures refer to paragraphs and not to pages, except where indicated to the contrary)

Arnold, Sir Th., 461.
Ashton, T. S., 481.
Aymard, A., 428.
Aymard, J., 407.

Berdiaeff, N., 427.
Bettelheim, Ch., 512.
Birnie, A., 482.
Bloch, M., 426, 428, 462.
Blumner, H., 429.
Boissonnada, P., 463.
Borkenau, F., 464.
Bratianu, G. I., 465.
Breasted, J. H., 430.
Brunet, P., 431.
Bury, J. B., 408.
Byé, M., 512.

Camichel, Ch., 428.
Carus-Wilson, E. M., 466.
Cassou, J., 426.
Chapot, V., 432.
Cheronnet, L., 426.
Clapham, J. H., 467.
Clark, G. N., 483.
Coulton, G. G., 468.
Cohen, M. R., 433.
Cressy, E., 484.

Delaruelle, Et., 428.
Dijksterhuis, E. J., 434, 469.
Drabkin, I. E., 433.
Ducassé, P., 409.
Duplessy, L., 485.
Durand, D. B., 470.
Durtain, L., 426.

Faucher, D., 428.
Febvre, L., 428.
Forbes, R. J., p. 7 and 410, 435, 436, 437, 438, 439.
Fourastié, J., 411, 486, 512.
Frank, T., 440.
Friedmann, G., p. 12 and 426, 428, 487, 488, 489, 512.

Garrod, D. A. E., 441.
Gest, A. P., 442.
Gilfillan, S. C., 412, 413.
Giraud, P., 443.
Girvin, H. F., 490.
Glanville, S. R. K., 444.
Glotz, G., 445.
Goeghagan, A. T., 446.
Goldenwieser, A. A., 491.
Grossmann, H., 471.
Guillaume, A., 461.
Gurvitch, G., 512.

Haldane, J. B. S., 427.
Hamilton, H., 492.
Hammond, J. L. and B., 493.
Harrison, H. S., 414.
Hatfield, H. S., 494.
Heaton, H., 495.
Hessen, B., 472.
Howland, W. E., 496.
Hughes, E. C., 512.

Kirby, R. S., 497.

Lalande, A., 428.
Lamer, H., 447.
Laski, H. I., 512.
Laurson, P. G., 497.
Le Corbusier, 426.
Lefebvre, H., 512.
Leroi-Gourhan, A., 415.
Luc, J., 426.

Mantoux, P., 498.
Mauss, M., 428.
Mendelsohn, I., 448.
Ménétrier, J., 499.
Merton, R. K., 500.
Meyerson, I., 428.
Mez, A., 473.
Michell, H., 449.
Mieli, A., 431.
Mounier, E., 427, 512.
Mumford, L., p. 10 and 416.

Nef, J. V., 474.

Oehser, P. H., 501.
Oertel, F., 450.
Ornstein, M., 475.
Ors, E. d', 427.

Parsons, R. H., 502.
Parsons, W. B., 476.
Peake, H., 451.
Pledge, H. T., 503.
Power, E., 467.
Praus, A. A., 417.
Prenant, M., 427.

Randall, J. H., 504.
Rehm, A., 452.
Renard, G., 505.
Romains, J., 506.
Rostovtzeff, M., 453, 454.

Salant, W., 455.
Sarton, G., 418, 419.
Sayce, R. U., 420.
Schuhl, P. M., 421.
Siddheswarananda, 427.
Siegfried, A., 427, 507.
Singer, Ch., 422.
Speiser, E. A., 456.
Spire, A., 426.
Stimson, D., 477.
Straub, H., 508.

Taylor, F. Sh., 423.
Theobald, W., 478.
Thornton, J. F., 509.
Torrey, H. B., 457.
Turner, R., 458.

Uccelli, A., 510.
Usher, A. P., 424.

Varagnac, A., 426, 512.
Vernant, J., 512.
Vignaux, P., 428.
Vowles, H. P., and M. W., 425.

Westermann, W. L., 459.
Weulersse, G., 505.
White, L., 479.
Wolf, A., 480, 511.
Wright, F. W., 460.

Zoretti, L., 426.

INDEX OF PERIODICALS

(The figures refer to paragraphs and not to pages, except where indicated to the contrary)

American Naturalist, 457.
Annales d'Histoire économique et sociale, 462.
Année sociologique, 427.
Archives Internationales d'Histoire des Sciences, 436, 437, 438.
Archiv für Kulturgeschichte, 452.

Civil Engineering, 496.

Economic History Review, 466, 474.
Europe, 426.

Isis, 417.

Journal de Psychologie, 428.
Journal of Economic History, 459.
Journal of the History of Ideas, 470.
Journal of the Patent Office Society, 413.

Man, 414.

Nature, 456.

Quarterly Journal of Economics, 500.

Revue des Etudes anciennes, 432.

Science Monthly, 455.
Speculum, 479.

The Classical Weekly, 460.

Zeitschrift für Sozialforschung, 471.

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